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1 CLAIMS:

2 1. A method for forming graded junction regions operatively
3 adjacent a transistor gate of CMOS circuitry, the method comprising the
4 following steps:

5 providing a semiconductor material wafer;

6 defining a PMOS region and an NMOS region of the wafer;

7 providing a PMOS transistor gate over the PMOS region and
8 providing an NMOS transistor gate over the NMOS region, the
9 transistor gates having opposing lateral sidewalls;

10 providing sidewall spacers adjacent the sidewalls of the transistor
11 gates, the sidewall spacers having a lateral thickness and comprising a
12 sidewall spacer material;

13 providing a masking layer over the PMOS region;

14 after providing the masking layer over the PMOS region, and after
15 providing the sidewall spacers adjacent the NMOS transistor gate,
16 implanting an n-type conductivity-enhancing dopant into the
17 semiconductor wafer to form electrically conductive NMOS source/drain
18 regions within the semiconductor material operatively adjacent the NMOS
19 transistor gate;

20 after forming the electrically conductive NMOS source/drain
21 regions, etching the sidewall spacer material adjacent the NMOS
22 transistor gate to remove only a portion of said spacer material and to
23 thereby decrease the lateral thickness of the sidewall spacers adjacent
24 the NMOS transistor gate; and

FIG. 2

1 after decreasing the lateral thickness of the sidewall spacers
2 adjacent the NMOS transistor gate, implanting a p-type conductivity-
3 enhancing dopant into the semiconductor material to form halo regions
4 operatively adjacent the NMOS source/drain regions.

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6 2. The method of claim 1 further comprising, after providing
7 transistor gates over the PMOS region and NMOS region, and prior to
8 providing sidewall spacers adjacent the sidewalls of the transistor gates,
9 forming NMOS LDD regions operatively adjacent the NMOS transistor
10 gate.
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3. The method of claim 1 further/comprising:

after forming the electrically conductive NMOS source/drain regions, and prior to etching the sidewall spacer material adjacent the NMOS transistor gate, stripping the masking layer from over the PMOS region;

etching the sidewall spacer material adjacent the PMOS transistor gate to decrease the lateral thickness of the sidewall spacers adjacent the PMOS transistor gate; and

after decreasing the lateral thickness of the sidewall spacers adjacent the NMOS transistor gate and the PMOS transistor gate, blanket implanting the p-type conductivity-enhancing dopant into the semiconductor material of both the PMOS region and the NMOS region to form halo regions operatively adjacent the NMOS transistor gate and to form PMOS LDD regions operatively adjacent the PMOS transistor gate.

4. The method of claim 3 further comprising, prior to decreasing the lateral thickness of the sidewall spacers adjacent the PMOS transistor gate and subsequent to stripping the masking layer from over the PMOS region, forming electrically conductive PMOS source/drain regions within the semiconductor material operatively adjacent the PMOS transistor gate.

1 5. The method of claim 1 further comprising, prior to
2 providing the masking layer over the PMOS region, forming PMOS LDD
3 regions operatively adjacent the PMOS transistor gate.

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5 6. The method of claim 1 wherein the semiconductor material
6 wafer comprises an overall planar global configuration, the planar global
7 configuration establishing a virtual planar top surface and an axis
8 normal to the virtual planar top surface, and wherein the p-type
9 conductivity-enhancing dopant is implanted at an angle other than
10 parallel to the axis normal to the virtual planar top surface.
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FIG. 10

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7. The method of claim 1 further comprising:
prior to providing the masking layer over the PMOS region,
forming PMOS LDD regions operatively adjacent the PMOS transistor
gate;
after forming the electrically conductive NMOS source/drain
regions, and prior to etching the sidewall spacer material adjacent the
NMOS transistor gate, stripping the masking layer from over the PMOS
region;
etching the sidewall spacer material adjacent the PMOS transistor
gate to decrease the lateral thickness of the sidewall spacers adjacent
the PMOS transistor gate; and
after decreasing the lateral thickness of the sidewall spacers
adjacent the NMOS transistor gate and the PMOS transistor gate,
blanket implanting the p-type conductivity-enhancing dopant into the
semiconductor material of both the PMOS region and the NMOS region
to form halo regions operatively adjacent the NMOS transistor gate and
to enhance the conductivity of the PMOS LDD regions.

8. The method of claim 1 wherein the semiconductor material wafer comprises an overall planar global configuration, the planar global configuration establishing a virtual planar top surface and an axis normal to the virtual planar top surface, and further comprising:

after forming the electrically conductive NMOS source/drain regions, and prior to etching the sidewall spacer material adjacent the NMOS transistor gate, stripping the masking layer from over the PMOS region;

etching the sidewall spacer material adjacent the PMOS transistor gate to remove only a portion of said spacer material and to thereby decrease the lateral thickness of the sidewall spacers adjacent the PMOS transistor gate; and

after decreasing the lateral thickness of the sidewall spacers adjacent the NMOS transistor gate and the PMOS transistor gate, blanket implanting the p-type conductivity-enhancing dopant at an angle other than parallel to the axis normal to the virtual planar top surface to form NMOS halo regions operatively adjacent the NMOS transistor gate and to form PMOS LDD regions operatively adjacent the PMOS transistor gate.

9. The method of claim 1 wherein the portion of spacer material removed from the sidewall spacers constitutes no more than about 90% of the lateral thickness of the sidewall spacers adjacent the NMOS transistor gate.

1 10. The method of claim 1 wherein the sidewalls of the
2 transistor gates comprise polysilicon, the method further comprising:

3 prior to providing sidewall spacers adjacent the sidewalls, oxidizing
4 the polysilicon of the sidewalls.

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6 11. The method of claim 10 further comprising, prior to
7 providing sidewall spacers adjacent the sidewalls of the NMOS transistor
8 gate, forming NMOS LDD regions operatively adjacent the NMOS
9 transistor gate.

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11 12. CMOS circuitry comprising at least one transistor formed by
12 the method of claim 1.
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13. A method for forming graded junction regions operatively adjacent a transistor gate, the method comprising the following steps:

providing a semiconductor material wafer;

providing a transistor gate over the semiconductor material wafer, the transistor gate having opposing lateral sidewalls;

providing sidewall spacers adjacent the sidewalls of the transistor gate, the sidewall spacers having a lateral thickness and comprising a sidewall spacer material;

after providing the sidewall spacers, implanting a first conductivity-enhancing dopant into the semiconductor wafer to form electrically conductive source/drain regions within the semiconductor material operatively adjacent the transistor gate;

after forming the electrically conductive source/drain regions, etching the sidewall spacer material to remove only a portion of said spacer material and to thereby decrease the lateral thickness of the sidewall spacers; and

after decreasing the lateral thickness of the sidewall spacers, implanting a second conductivity-enhancing dopant into the semiconductor material to form graded junction regions operatively adjacent the source/drain regions.

14. The method of claim 13 wherein the semiconductor material wafer comprises an overall planar global configuration, the planar global configuration establishing a virtual planar top surface and an axis normal to the virtual planar top surface, and wherein the second conductivity-enhancing dopant is implanted at an angle other than parallel to the axis normal to the virtual planar top surface.

15. The method of claim 13 wherein the transistor is a PMOS transistor, the second conductivity-enhancing dopant is a p-type dopant, and the implant of the second conductivity-enhancing dopant forms LDD regions operatively adjacent the PMOS source/drain regions.

16. The method of claim 13 wherein the transistor is a PMOS transistor, the second conductivity-enhancing dopant is an n-type dopant, and the implant of the second conductivity-enhancing dopant forms halo regions operatively adjacent the PMOS source/drain regions.

17. The method of claim 16 wherein the second conductivity-enhancing dopant comprises phosphorus.

18. The method of claim 13 wherein the transistor is an NMOS transistor, the second conductivity-enhancing dopant is a p-type dopant, and the implant of the second conductivity-enhancing dopant forms halo regions operatively adjacent the NMOS source/drain regions.

19. The method of claim 18 wherein the second conductivity-enhancing dopant comprises boron.

20. The method of claim 13 wherein the transistor is an NMOS transistor, the second conductivity-enhancing dopant is a n-type dopant, and the implant of the second conductivity-enhancing dopant forms LDD regions operatively adjacent the NMOS source/drain regions.

21. A transistor formed by the method of claim 13.

22. A method for implanting graded junction regions into a peripheral NMOS transistor and source/drain regions into a memory array of NMOS transistors, the method comprising the following steps:

- providing a semiconductor material wafer;
- defining a memory array region of the wafer;
- defining a PMOS region and a peripheral NMOS region of the wafer;

providing a PMOS transistor gate over the PMOS region, providing a peripheral NMOS transistor gate over the peripheral NMOS region, and providing an array of memory NMOS transistor gates over the memory array region, the transistor gates having opposing lateral sidewalls;

providing sidewall spacers adjacent the sidewalls of the transistor gates, the sidewall spacers having a lateral thickness and comprising a sidewall spacer material;

providing a masking layer over the PMOS region and over the memory array region;

after providing the masking layer over the PMOS region and the memory array region, and after providing the sidewall spacers adjacent the peripheral NMOS transistor gate, implanting an n-type conductivity-enhancing dopant into the semiconductor wafer to form electrically conductive peripheral NMOS source/drain regions within the semiconductor material operatively adjacent the peripheral NMOS transistor gate;

after forming the electrically conductive NMOS source/drain regions, etching the sidewall spacer material adjacent the peripheral NMOS transistor gate to remove only a portion of said spacer material and to thereby decrease the lateral thickness of the sidewall spacers adjacent the peripheral NMOS transistor gate; and

after decreasing the lateral thickness of the sidewall spacers adjacent the peripheral NMOS transistor gate, implanting p-type conductivity-enhancing dopant into the semiconductor material to form halo regions operatively adjacent the peripheral NMOS source/drain regions.

23. The method of claim 22 further comprising, after providing transistor gates over the peripheral NMOS region and over the memory array region, and prior to providing sidewall spacers adjacent the sidewalls of the transistor gates, providing LDD regions operatively adjacent the peripheral NMOS transistor gate and providing memory gate source/drain regions operatively adjacent the memory NMOS transistor gates.

24. The method of claim 22 further comprising:
 after forming halo regions operatively adjacent the NMOS source/drain regions, stripping the masking layer from over the PMOS region and providing a masking layer over the peripheral NMOS region;
 after providing the masking layer over the NMOS region, etching the sidewall spacer material adjacent the PMOS transistor gate to decrease the lateral thickness of the sidewall spacers adjacent the PMOS transistor gate; and
 after decreasing the lateral thickness of the sidewall spacers adjacent the PMOS transistor gate, implanting n-type conductivity-enhancing dopant into the semiconductor material to form halo regions operatively adjacent the PMOS transistor gate.

25. The method of claim 24 further comprising, prior to decreasing the lateral thickness of the sidewall spacers adjacent the PMOS transistor gate and subsequent to stripping the masking layer from over the PMOS region, forming electrically conductive PMOS source/drain regions within the semiconductor material operatively adjacent the PMOS transistor gate.

26. The method of claim 22 further comprising:

after forming halo regions operatively adjacent the NMOS source/drain regions, stripping the masking layer from over the PMOS region and providing a masking layer over the peripheral NMOS region;

after providing the masking layer over the NMOS region, etching the sidewall spacer material adjacent the PMOS transistor gate to decrease the lateral thickness of the sidewall spacers adjacent the PMOS transistor gate; and

after decreasing the lateral thickness of the sidewall spacers adjacent the PMOS transistor gate, implanting p-type conductivity-enhancing dopant into the semiconductor material to form LDD regions operatively adjacent the PMOS transistor gate.

27. The method of claim 26 further comprising, prior to decreasing the lateral thickness of the sidewall spacers adjacent the PMOS transistor gate and subsequent to stripping the masking layer from over the PMOS region, forming electrically conductive PMOS source/drain regions within the semiconductor material operatively adjacent the PMOS transistor gate.

28. The method of claim 22 further comprising:

after forming the electrically conductive peripheral NMOS source/drain regions, and prior to etching the sidewall spacer material adjacent the peripheral NMOS transistor gate, stripping the masking layer from over the PMOS region;

etching the sidewall spacer material adjacent the PMOS transistor gate to decrease the lateral thickness of the sidewall spacers adjacent the PMOS transistor gate; and

after decreasing the lateral thickness of the sidewall spacers adjacent the peripheral NMOS transistor gate and the PMOS transistor gate, blanket implanting the p-type conductivity-enhancing dopant into the semiconductor material of both the PMOS region and the NMOS region to form halo regions operatively adjacent the NMOS transistor gate and to form PMOS LDD regions operatively adjacent the PMOS transistor gate.

1 29. The method of claim 28 further comprising, prior to
2 decreasing the lateral thickness of the sidewall spacers adjacent the
3 PMOS transistor gate and subsequent to stripping the masking layer
4 from over the PMOS region, forming electrically conductive PMOS
5 source/drain regions within the semiconductor material operatively
6 adjacent the PMOS transistor gate.

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8 30. A semiconductor wafer comprising a peripheral NMOS and
9 a memory array formed by the method of claim 22.

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11 31. A method for forming graded junction regions operatively
12 adjacent a transistor gate, the method comprising the following steps:
13 providing a semiconductor material wafer;
14 providing a transistor gate over the semiconductor material wafer,
15 the transistor gate having opposing lateral sidewalls;
16 providing sidewall spacers adjacent the sidewalls of the transistor
17 gate, the sidewall spacers having a lateral thickness and comprising a
18 sidewall spacer material;
19 decreasing the lateral thickness of the sidewall spacers by
20 removing only a portion of the sidewall spacers; and
21 after decreasing the lateral thickness of the sidewall spacers,
22 implanting a conductivity-enhancing dopant into the semiconductor
23 material to form graded junction regions operatively adjacent the
24 transistor gate.

32. The method of claim 31 wherein the semiconductor material wafer comprises an overall planar global configuration, the planar global configuration establishing a virtual planar top surface and an axis normal to the virtual planar top surface, and wherein the second conductivity-enhancing dopant is implanted at an angle other than parallel to the axis normal to the virtual planar top surface.

33. The method of claim 31 further comprising, after providing the sidewall spacers and prior to decreasing the lateral thickness of the sidewall spacers, providing electrically conductive source/drain regions operatively adjacent the transistor gate.

34. The method of claim 31 further comprising incorporating the transistor gate into a PMOS transistor, wherein the implanted conductivity-enhancing dopant is a p-type dopant, and wherein the formed graded junction regions are LDD regions.

35. The method of claim 31 further comprising incorporating the transistor gate into a PMOS transistor, wherein the implanted conductivity-enhancing dopant is an n-type dopant, and wherein the formed graded junction regions are halo regions.

1 36. The method of claim 31 further comprising incorporating the
2 transistor gate into an NMOS transistor, wherein the implanted
3 conductivity-enhancing dopant is a p-type dopant, and wherein the
4 formed graded junction regions are halo regions.

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6 37. The method of claim 31 further comprising incorporating the
7 transistor gate into an NMOS transistor, wherein the implanted
8 conductivity-enhancing dopant is an n-type dopant, and wherein the
9 formed graded junction regions are LDD regions.

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11 38. A transistor formed by the method of claim 31.
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39. A semiconductor transistor device comprising:

a region of a semiconductor material wafer;

a transistor gate over a portion of the region of the semiconductor material wafer, the transistor gate having opposing lateral sidewalls;

opposing source/drain regions operatively adjacent the transistor gate, each source/drain region having an inner lateral boundary;

opposing sidewall spacers adjacent the sidewalls of the transistor gate, each sidewall spacer having an outer lateral edge, the sidewall spacers and source/drain regions being paired such that the outer lateral edges of the sidewall spacers are displaced laterally inwardly relative to the inner lateral boundaries of the source/drain regions; and

lateral gaps, the lateral gaps extending from the outer lateral edges of the sidewall spacers to the inner lateral boundaries of the source/drain regions.

40. The device of claim 39 wherein the lateral gaps have a length, the length of the lateral gaps being from about 200 Angstroms to about 600 Angstroms.

41. The device of claim 39 further comprising graded junction regions inwardly adjacent the source/drain regions, the graded junction regions extending within the lateral gaps.

42. A method for forming a peripheral NMOS transistor and one or more memory NMOS transistors, the method comprising the following steps:

forming a peripheral NMOS transistor gate and one or more memory NMOS transistor gates;

forming source/drain regions, halo regions and LDD regions operatively adjacent the peripheral NMOS transistor gate, and forming source/drain regions operatively adjacent the one or more memory NMOS transistor gates, the steps of forming the regions occurring in a sequence such that one or more of the regions are formed last and are therefore last formed regions, wherein the LDD regions formed operatively adjacent the peripheral NMOS transistor gate are not the last formed regions; and

less than two masking layer provision steps after the formation of the LDD regions operatively adjacent the peripheral NMOS transistor gate, and prior to formation of the one or more last formed regions.

43. A method for forming graded junction regions operatively adjacent a transistor gate of CMOS circuitry, the method comprising the following steps:

providing a semiconductor material wafer;

defining a PMOS region and an NMOS region of the wafer;

providing a gate layer over the PMOS region and over the NMOS region;

1 patterning the gate layer over the NMOS region to form an
2 NMOS transistor gate over the NMOS region while leaving the gate
3 layer over the PMOS region unpatterned, the NMOS transistor gate
4 having opposing lateral sidewalls;

5 providing sidewall spacers adjacent the sidewalls of the NMOS
6 transistor gate, the sidewall spacers having a lateral thickness and
7 comprising a sidewall spacer material;

8 after providing the sidewall spacers, forming electrically conductive
9 NMOS source/drain regions within the semiconductor material operatively
10 adjacent the NMOS transistor gate;

11 after forming the electrically conductive NMOS source/drain
12 regions, etching the sidewall spacer material adjacent the NMOS
13 transistor gate to remove only a portion of said spacer material and to
14 thereby decrease the lateral thickness of the sidewall spacers; and

15 after decreasing the lateral thickness of the sidewall spacers
16 adjacent the NMOS transistor gate, implanting conductivity-enhancing
17 dopant into the semiconductor material to thereby form NMOS graded
18 junction regions operatively adjacent the NMOS source/drain regions.

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20 44. The method of claim 43 wherein the implanted conductivity-
21 enhancing dopant is a p-type dopant and wherein the formed NMOS
22 graded junction regions are halo regions.
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1 45. The method of claim 43 wherein the portion of spacer
2 material removed from the sidewall spacers constitutes no more than
3 about 90% of the lateral thickness of the sidewall spacers adjacent the
4 NMOS transistor gate.

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6 46. The method of claim 43 wherein the gate layer comprises
7 a polysilicon layer, a refractory metal layer over the polysilicon layer,
8 an oxide layer over the refractory metal layer, and a silicon nitride
9 layer over the oxide layer.

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11 47. The method of claim 43 further comprising, after forming
12 the NMOS transistor gate, and prior to providing sidewall spacers,
13 forming NMOS LDD regions operatively adjacent the NMOS transistor
14 gate.

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16 48. The method of claim 43 wherein the opposing lateral
17 sidewalls of the NMOS transistor gate comprise polysilicon, the method
18 further comprising:

19 prior to providing sidewall spacers adjacent the NMOS transistor
20 gate, oxidizing the polysilicon of the opposing lateral sidewalls to form
21 an oxide layer along each opposing lateral sidewall.
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1 49. The method of claim 48 further comprising, after forming
2 the NMOS transistor gate, and prior to providing the oxide layer along
3 each opposing lateral sidewall, forming NMOS LDD regions operatively
4 adjacent the NMOS transistor gate.

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6 50. The method of claim 43 wherein the semiconductor material
7 wafer comprises an overall planar global configuration, the planar global
8 configuration establishing a virtual planar top surface and an axis
9 normal to the virtual planar top surface, and wherein the p-type
10 conductivity-enhancing dopant is implanted at an angle other than
11 parallel to the axis normal to the virtual planar top surface.

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13 51. The method of claim 43 further comprising:
14 after forming the NMOS transistor gate, patterning the gate layer
15 over the PMOS region to form a PMOS transistor gate over the PMOS
16 region.

52. A method for implanting graded junction regions into a peripheral NMOS transistor and into a memory array of NMOS transistors, the method comprising the following steps:

providing a semiconductor material wafer;

defining a memory array region, a PMOS region and a peripheral NMOS region of the wafer;

providing a gate layer over the PMOS, peripheral NMOS and memory array regions;

patterning the gate layer over the peripheral NMOS region to form a peripheral NMOS transistor gate over the peripheral NMOS region, the peripheral NMOS transistor gate having opposing lateral sidewalls;

patterning the gate layer over the memory array region to form an array of memory NMOS transistor gates over the memory array region, the memory NMOS transistor gates having opposing lateral sidewalls;

while patterning the gate layer over the peripheral NMOS region, and while patterning the gate layer over the memory array region, leaving the gate layer over the PMOS region unpatterned;

providing sidewall spacers adjacent the sidewalls of the peripheral and memory NMOS transistor gates, the sidewall spacers having a lateral thickness and comprising a sidewall spacer material;

1 after providing the sidewall spacers forming electrically conductive
2 peripheral NMOS source/drain regions within the semiconductor material
3 operatively adjacent the peripheral NMOS transistor gate;

4 after forming the electrically conductive NMOS source/drain
5 regions, etching the sidewall spacer material adjacent the peripheral
6 NMOS transistor gate to remove only a portion of said spacer material
7 and to thereby decrease the lateral thickness of the sidewall spacers
8 adjacent the peripheral NMOS transistor gate; and

9 after decreasing the lateral thickness of the sidewall spacers
10 adjacent the peripheral NMOS transistor gate, implanting conductivity-
11 enhancing dopant into the semiconductor material to form peripheral
12 NMOS graded junction regions operatively adjacent the peripheral NMOS
13 transistor gate.

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15 53. The method of claim 52 wherein the semiconductor material
16 wafer comprises an overall planar global configuration, the planar global
17 configuration establishing a virtual planar top surface and an axis
18 normal to the virtual planar top surface, and wherein the p-type
19 conductivity-enhancing dopant is implanted at an angle other than
20 parallel to the axis normal to the virtual planar top surface.

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22 54. The method of claim 52 wherein the implanted conductivity-
23 enhancing dopant is a p-type dopant and wherein the formed NMOS
24 graded junction regions are halo regions.

regions operatively adjacent the peripheral NMOS transistor gate and forming memory NMOS source/drain regions operatively adjacent the memory NMOS transistor gates.

59. The method of claim 52 further comprising:

after forming halo regions operatively adjacent the NMOS source/drain regions, providing a masking layer over the peripheral NMOS region;

after providing the masking layer over the peripheral NMOS region, patterning a PMOS transistor gate over the PMOS region; and forming electrically conductive PMOS source/drain regions operatively adjacent the PMOS transistor gate.

60. The method of claim 59 further comprising forming PMOS graded junction regions operatively adjacent the PMOS source/drain regions.

61. The method of claim 59 further comprising forming PMOS graded junction regions operatively adjacent the PMOS source/drain regions, wherein the PMOS graded junction regions are formed after the PMOS source/drain regions are formed.

62. The method of claim 59 wherein the PMOS transistor gate has opposing lateral sidewalls, and further comprising:

providing sidewall spacers adjacent the sidewalls of the PMOS transistor gate, the sidewall spacers having a lateral thickness and comprising a sidewall spacer material;

after forming the electrically conductive PMOS source/drain regions, etching the sidewall spacer material adjacent the PMOS transistor gate to remove only a portion of said spacer material and to thereby decrease the lateral thickness of the sidewall spacers adjacent the PMOS transistor gate; and

after decreasing the lateral thickness of the sidewall spacers adjacent the PMOS transistor gate, implanting conductivity-enhancing dopant into the semiconductor material of the PMOS region to form PMOS graded junction regions operatively adjacent the PMOS transistor gate.

63. The method of claim 59 wherein the PMOS transistor gate has a top and pair of opposing lateral sidewalls, and further comprising:

providing an overhanging PMOS capping layer over the top of the PMOS transistor gate, the capping layer extending laterally outward beyond the pair of opposing lateral sidewalls;

after providing the capping layer, implanting p-type conductivity-enhancing dopant into the semiconductor material of the PMOS region to form the electrically conductive source/drain regions operatively adjacent the PMOS transistor gate, the overhanging capping layer offsetting the PMOS source/drain regions from the PMOS transistor gate;

1 removing the overhanging capping layer from the top of the
2 PMOS transistor gate; and

3 implanting a conductivity-enhancing dopant into the semiconductor
4 material of the PMOS region to form PMOS graded junction regions
5 operatively adjacent the PMOS source/drain regions.
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FIG. 10

FIG. 1

64. A method for forming graded junction regions operatively adjacent a transistor gate, the method comprising the following steps:

providing a semiconductor material wafer;

providing a transistor gate over the semiconductor material wafer, the transistor gate comprising a layer of polysilicon and having opposing lateral sidewalls which include an exposed portion of the layer of polysilicon;

forming an oxide layer along the exposed portion of the layer of polysilicon of the lateral sidewalls;

providing sidewall spacers adjacent the sidewalls of the transistor gate and adjacent the oxide layer, the sidewall spacers having a lateral thickness and comprising a sidewall spacer material;

after providing the sidewall spacers, implanting a first conductivity-enhancing dopant into the semiconductor wafer to form electrically conductive source/drain regions within the semiconductor material operatively adjacent the transistor gate;

after forming the electrically conductive source/drain regions, etching the sidewall spacer material adjacent the transistor gate to remove said sidewall spacers and to thereby expose the oxide layer; and

after exposing the oxide layer, implanting a second conductivity-enhancing dopant into the semiconductor material to form graded junction regions operatively adjacent the transistor gate.

65. The method of claim 64 further comprising, prior to forming the oxide layer along the exposed portion of the layer of polysilicon, forming graded junction regions operatively adjacent the transistor gate.

66. The method of claim 64 wherein the first conductivity-enhancing dopant is p-type, the second conductivity-enhancing dopant is n-type, and the implant of the second conductivity enhancing dopant forms halo regions.

67. The method of claim 64 wherein the first conductivity-enhancing dopant is p-type, the second conductivity-enhancing dopant is p-type, and the implant of the second conductivity enhancing dopant forms LDD regions.

68. The method of claim 64 wherein the first conductivity-enhancing dopant is n-type, the second conductivity-enhancing dopant is n-type, and the implant of the second conductivity enhancing dopant forms LDD regions.

69. The method of claim 64 wherein the first conductivity-enhancing dopant is n-type, the second conductivity-enhancing dopant is p-type, and the implant of the second conductivity enhancing dopant forms halo regions.

1 70. A method for forming a peripheral NMOS transistor and a
2 memory array of NMOS transistors, the method comprising the following
3 steps:

4 providing a semiconductor material wafer;

5 defining a memory array region, a PMOS region and a peripheral
6 NMOS region of the wafer;

7 providing a gate layer over the PMOS, peripheral NMOS and
8 memory array regions, the gate layer comprising a layer of polysilicon;

9 patterning the gate layer over the peripheral NMOS region to
10 form a peripheral NMOS transistor gate, the peripheral NMOS transistor
11 gate having opposing lateral sidewalls which include an exposed portion
12 of the layer of polysilicon;

13 patterning the gate layer over the memory array region to form
14 an array of memory NMOS transistor gates over the memory array
15 region, the memory NMOS transistor gates having opposing lateral
16 sidewalls which include an exposed portion of the layer of polysilicon;

17 while patterning the gate layer over the peripheral NMOS region,
18 and while patterning the gate layer over the memory array regions,
19 leaving the gate layer over the PMOS region unpatterned;

20 forming an oxide layer along the exposed portion of the layer of
21 polysilicon of the lateral sidewalls of the peripheral NMOS transistor
22 gate and along the exposed portions of the layer of polysilicon of the
23 lateral sidewalls of the memory NMOS transistor gates;

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1 providing sidewall spacers adjacent the sidewalls of the peripheral
2 and memory NMOS transistor gates and adjacent the oxide layers;

3 after providing the sidewall spacers, forming electrically conductive
4 peripheral NMOS source/drain regions within the semiconductor material
5 operatively adjacent the peripheral NMOS transistor gate;

6 after forming the electrically conductive NMOS source/drain
7 regions, removing the sidewall spacers from adjacent the peripheral
8 NMOS transistor gate; and

9 after removing the sidewall spacers, implanting conductivity-
10 enhancing dopant into the semiconductor material to form peripheral
11 NMOS graded junction regions operatively adjacent the peripheral NMOS
12 transistor gate.

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14 71. The method of claim 70 further comprising, prior to forming
15 the oxide layer along the exposed portion of the layer of polysilicon of
16 the lateral sidewalls of the peripheral NMOS transistor gate and along
17 the exposed portions of the layer of polysilicon of the lateral sidewalls
18 of the memory NMOS transistor gates, providing peripheral NMOS LDD
19 regions operatively adjacent the peripheral NMOS transistor gate and
20 providing electrically-conductive memory array source/drain operatively
21 adjacent the memory array transistor gates.
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72. The method of claim 70 wherein the implant of conductivity-enhancing dopant into the semiconductor material comprises implanting p-type conductivity enhancing dopant and thereby forms peripheral NMOS halo regions operatively adjacent the peripheral NMOS transistor gate.

73. The method of claim 70 further comprising, prior to forming the oxide layer along the exposed portion of the layer of polysilicon of the lateral sidewalls of the peripheral NMOS transistor gate and along the exposed portions of the layer of polysilicon of the lateral sidewalls of the memory NMOS transistor gates, providing peripheral NMOS LDD regions operatively adjacent the peripheral NMOS transistor gate and providing electrically-conductive memory array source/drain operatively adjacent the memory array transistor gates; and wherein the implant of conductivity-enhancing dopant into the semiconductor material comprises implanting p-type conductivity enhancing dopant and thereby forms peripheral NMOS halo regions operatively adjacent the peripheral NMOS transistor gate.

74. The method of claim 70 further comprising, after providing sidewall spacers adjacent the sidewalls of the peripheral and memory NMOS transistor gates, and prior to forming electrically-conductive NMOS source/drain regions, providing a masking layer over the memory array region.

76. A method for forming a transistor device, the method comprising the following steps:

providing a semiconductor material wafer, the semiconductor wafer having a surface;

providing a transistor gate layer atop the surface of the semiconductor wafer, the transistor gate comprising an upper oxide layer and an insulative cap layer over the upper oxide layer, the upper oxide layer having an upper surface, the upper oxide upper surface being at a level above the surface of the semiconductor wafer, the insulative cap comprising an insulative cap material;

providing a masking layer over the transistor gate and over the surface of the semiconductor substrate, the masking layer having an upper surface and comprising a masking layer material;

removing masking layer material from over the transistor gate until the masking layer upper surface is about level with the level of the upper surface of the upper oxide layer; and

etching the insulative cap material to remove the insulative cap from over the transistor gate to thereby expose the upper surface of the upper oxide layer.

77. The method of claim 76 wherein the masking layer material comprises photoresist.

1 78. The method of claim 76 wherein the insulative cap material
2 comprises silicon nitride.
3

4 79. The method of claim 76 wherein the transistor gate
5 comprises opposing lateral sidewalls, the method further comprising:

6 after forming the transistor gate, providing sidewall spacers
7 adjacent the opposing lateral sidewalls of the transistor gate, the
8 sidewalls having a top surface, the top surface of the sidewall spacers
9 being elevationally above the upper surface of the upper oxide layer;
10 and

11 etching the sidewall spacers to form flat top surfaces of the
12 sidewall spacers, the flat top surfaces being elevationally at about the
13 same level as the exposed upper surface of the upper oxide layer of
14 the transistor gate.
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1 80. The method of claim 76 wherein the transistor gate
2 comprises opposing lateral sidewalls, the method further comprising:

3 after forming the transistor gate, providing sidewall spacers
4 adjacent the opposing lateral sidewalls of the transistor gate, the
5 sidewalls having a top surface, the top surface of the sidewall spacers
6 being elevationally above the upper surface of the upper oxide layer,
7 the sidewall spacers comprising a sidewall spacer material which is
8 identical to the material of the insulative cap; and

9 etching the sidewall spacer material to form flat top surfaces of
10 the sidewall spacers, the flat top surfaces being elevationally at about
11 the same level as the exposed upper surface of the upper oxide layer
12 of the transistor gate, the etching of the sidewall spacer material
13 occurring concurrently with the etching of the insulative cap material.

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15 81. The method of claim 80 wherein the insulative cap material
16 and the sidewall spacer material both comprise silicon nitride.
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82. A method for forming CMOS circuitry, the method comprising the following steps:

providing a semiconductor material wafer, the semiconductor wafer having a surface;

defining a PMOS region and an NMOS region of the wafer;

providing a gate layer over the PMOS region and over the NMOS region, the gate layer having an upper oxide layer and an insulative cap over the upper oxide layer, the upper oxide layer having an upper surface, the upper oxide upper surface being at a level above the surface of the semiconductor wafer, the insulative cap comprising an insulative cap material;

patterning the gate layer over the NMOS region to form an NMOS transistor gate over the NMOS region while leaving the gate layer over the PMOS region unpatterned;

providing a masking layer over the PMOS region and the NMOS region, the masking layer having an upper surface and comprising a masking layer material;

removing masking layer material from over the PMOS and NMOS regions until the masking layer upper surface is about level with the level of the upper surface of the upper oxide layer; and

etching the insulative cap material to remove the insulative cap from over the NMOS gate and from over the unpatterned gate layer over the PMOS region to thereby expose the upper surface of the upper oxide layer of the NMOS gate and to also thereby expose the

1 upper surface of the upper oxide layer of the unpatterned gate layer
2 over the PMOS region.

3
4 83. The method of claim 82 wherein the masking layer material
5 comprises photoresist.

6
7 84. The method of claim 82 wherein the insulative cap material
8 comprises silicon nitride.

9
10 85. The method of claim 82 wherein the NMOS transistor gate
11 comprises opposing lateral sidewalls, the method further comprising:

12 after forming the NMOS transistor gate, providing sidewall spacers
13 adjacent the opposing lateral sidewalls of the NMOS transistor gate, the
14 sidewalls having a top surface, the top surface of the sidewall spacers
15 being elevationally above the upper surface of the upper oxide layer;
16 and

17 etching the sidewall spacers to form flat top surfaces of the
18 sidewall spacers, the flat top surfaces being elevationally at about the
19 same level as the exposed upper surface of the upper oxide layer of
20 the NMOS gate.

1 86. The method of claim 82 wherein the NMOS transistor gate
2 comprises opposing lateral sidewalls, the method further comprising:

3 after forming the NMOS transistor gate, providing sidewall spacers
4 adjacent the opposing lateral sidewalls of the NMOS transistor gate, the
5 sidewalls having a top surface, the top surface of the sidewall spacers
6 being elevationally above the upper surface of the upper oxide layer,
7 the sidewall spacers comprising a sidewall spacer material which is
8 identical to the material of the insulative cap; and

9 etching the sidewall spacer material to form flat top surfaces of
10 the sidewall spacers, the flat top surfaces being elevationally at about
11 the same level as the exposed upper surface of the upper oxide layer
12 of the NMOS gate, the etching of the sidewall spacer material occurring
13 concurrently with the etching of the insulative cap material.
14

15 87. The method of claim 86 wherein the insulative cap material
16 and the sidewall spacer material both comprise silicon nitride.
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1 88. A method for forming an NMOS transistor device and an
2 insulated word line, the method comprising the following steps:

3 providing a semiconductor material wafer, the semiconductor wafer
4 having a surface;

5 defining a memory array region of the wafer and a peripheral
6 NMOS region of the wafer;

7 providing a gate layer over the peripheral NMOS and memory
8 array regions of the wafer, the gate layer having an upper oxide layer
9 and an insulative cap over the upper oxide layer, the upper oxide layer
10 having an upper surface, the upper oxide layer upper surface being at
11 a level above the surface of the semiconductor wafer, the insulative cap
12 comprising an insulative cap material;

13 patterning the gate layer over the peripheral NMOS region to
14 form a peripheral NMOS transistor gate over the peripheral NMOS
15 region, the peripheral NMOS transistor gate having opposing lateral
16 sidewalls;

17 patterning the gate layer over the memory array region to form
18 a word line, the word line having opposing lateral sidewalls;

19 providing insulative sidewall spacers adjacent the opposing lateral
20 sidewalls of the peripheral NMOS transistor gate and adjacent the
21 opposing lateral sidewalls of the word line, the sidewall spacers
22 comprising a sidewall spacer material;

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1 providing a masking layer over the peripheral NMOS region, the
2 masking layer having an upper surface and comprising a masking layer
3 material;

4 removing the masking layer material from over peripheral NMOS
5 region until the masking layer upper surface is about level with the
6 upper oxide layer upper surface; and

7 removing the insulative cap material from over the peripheral
8 NMOS transistor gate to expose the upper oxide upper surface of the
9 peripheral NMOS gate.

10
11 89. The method of claim 88 further comprising:

12 prior to removing the masking layer material from over the
13 peripheral NMOS transistor gate, providing a masking layer over the
14 word line, the masking layer over the word line comprising a masking
15 layer material identical to the masking material of the masking layer
16 over the peripheral NMOS transistor gate, the masking layer material
17 over the word line having an upper surface which is elevationally above
18 the upper surface of the masking material over the peripheral NMOS
19 transistor gate; and

20 wherein the step of removing the masking layer material from
21 over peripheral NMOS region leaves masking layer material over the
22 word line.
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1 90. The method of claim 88 further comprising:
2 prior to removing the insulative cap from over the peripheral
3 NMOS transistor gate, providing a masking layer over the word line.
4

5 91. The method of claim 88 further comprising:
6 defining a PMOS region of the semiconductor material wafer;
7 providing the gate layer over the PMOS region;
8 while patterning the gate layer over the peripheral NMOS region,
9 and while patterning the gate layer over the memory array region,
10 leaving the gate layer over the PMOS region unpatterned; and
11 while providing the masking layer over the peripheral NMOS
12 region, also providing the masking layer over the PMOS region.
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92. The method of claim 88 further comprising:
defining a PMOS region of the semiconductor material wafer;
providing the gate layer over the PMOS region;
while patterning the gate layer over the peripheral NMOS region,
and while patterning the gate layer over the memory array region,
leaving the gate layer over the PMOS region unpatterned;
while providing the masking layer over the peripheral NMOS
region, also providing the masking layer over the PMOS region;
wherein the step of removing the masking layer material from
over peripheral NMOS region also removes masking layer material from
over the PMOS region; and
wherein the step of removing the insulative cap material from
over the peripheral NMOS transistor gate to expose the upper oxide
upper surface of the peripheral NMOS gate also removes insulative cap
material from over the PMOS region to expose an upper oxide surface
of the unpatterned masking material over the PMOS region.

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1 93. The method of claim 88 wherein the sidewall spacers of the
2 peripheral NMOS transistor have a top surface, the top surfaces of the
3 sidewall spacers being elevationally above the upper surface of the
4 upper oxide layer of the peripheral NMOS transistor, the method
5 further comprising:

6 etching the sidewall spacers of the peripheral NMOS transistor to
7 form flat top surfaces of the sidewall spacers of the peripheral NMOS
8 transistor, the flat top surfaces being elevationally at about the same
9 level as the exposed upper surface of the upper oxide layer of the
10 peripheral NMOS gate.
11

12 94. The method of claim 88 wherein the sidewall spacers of the
13 peripheral NMOS transistor have a top surface, the top surfaces of the
14 sidewall spacers being elevationally above the upper surface of the
15 upper oxide layer of the peripheral NMOS transistor, the method
16 further comprising:

17 etching the sidewall spacer material of the peripheral NMOS
18 transistor to form flat top surfaces of the sidewall spacers of the
19 peripheral NMOS transistor, the flat top surfaces being elevationally at
20 about the same level as the exposed upper surface of the upper oxide
21 layer of the peripheral NMOS gate, the etching of the sidewall spacer
22 material occurring concurrently with the etching of the insulative cap
23 material.
24

1 95. The method of claim 88 further comprising patterning the
2 gate layer over the memory array region to form memory transistor
3 gates.

4
5 96. The method of claim 88 wherein the insulative cap material
6 and the sidewall spacer material both comprise silicon nitride.
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FIG. 10

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97. A method for forming a PMOS transistor device, a peripheral NMOS transistor device, and one or more memory NMOS transistor devices, the method comprising the following steps:

providing a semiconductor material wafer;

defining a PMOS region, a peripheral NMOS region, and a memory array region of the wafer;

providing a gate layer over the PMOS, peripheral NMOS and memory array regions;

patterning the gate layer over the peripheral NMOS region to form a peripheral NMOS transistor gate;

patterning the gate layer over the memory array region to form one or more memory array transistor gates;

while patterning the gate layer over the peripheral NMOS and memory array regions, leaving the gate layer over the PMOS region unpatterned;

forming source/drain regions, halo regions and LDD regions operatively adjacent the peripheral NMOS transistor gate, and forming source/drain regions operatively adjacent the one or more memory NMOS transistor gates, the steps of forming the regions occurring in a sequence such that one or more of the regions are formed last and are therefore last formed regions; and

less than two masking layer provision steps after the formation of the peripheral NMOS transistor gate, and prior to the formation of the one or more last formed regions.

1 98. A method of forming a transistor structure on a
2 semiconductor substrate, comprising the following steps:

3 providing a transistor gate assembly formed on said substrate, said
4 gate assembly including sidewall spacers extending to said substrate;

5 doping a first region of said substrate with a selected dopant;

6 removing a lateral portion of at least one of said sidewall spacers,
7 while leaving a part of said at least one of said sidewall spacers in
8 place; and

9 after said removal, doping a second portion of said substrate.
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